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THE IMPACT OF THE DIGITAL ECONOMY ON LABOUR PRODUCTIVITY IN SERBIA: APPLICATION OF THE ARDL AND ECM APPROACHES

Abstract
Digital technologies have changed the way of people life, their business and behaviour by penetrating all aspects of their everyday life. They influence the development of the economy and society by enabling access to information and resources, connectivity, a more efficient decision-making process, financial inclusion, more advanced business strategies, as well as better access to trade and public services. Digital transformation encourages cooperation, flexibility, communication, efficiency and agility, but also innovation, conflict management, business sustainability, productivity growth, knowledge and general competencies of employees. On the other hand, labour productivity determines competitiveness, the pace of progress and the quality of the economy itself. The purpose of this article is to investigate the long-term and short-term relationship among some indicators of the digital sector and labour productivity in Serbia in the period from 2007 to 2021. While the applied Autoregressive Distributed

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Lags (ARDL) Model indicated that there is no long-term relationship between these phenomena, the applied Error Correction Model (ECM) indicated their short-term relationship. It was also observed that last year's productivity of employees statistically significantly and positively determines their current productivity. The article concludes that the government should continue to encourage the development of the digital economy in Serbia in order for it to grow into one of the main levers for the societal development, and therefore competitiveness and the economy as a whole.

Key words: *information and communication technologies (ICTs), digital economy, ARDL and ECM models, labour productivity, digital transformation.*

JEL classification: C32, L86, O00, O30

Introduction

Digital technologies have long penetrated in everyday business life, adapting to the rapid and unpredictable changes of the modern globalized marketplace. Digital transformation is present in all spheres of modern business life, changing business strategies and models, the way of life, decision-making process, behaviour and work, as well as people's habits, perception and daily routine. Today, digital technologies are engaged in many spheres of business and social life, encouraging cooperation, flexibility, communication, efficiency and agility, but also innovation, conflict management, business sustainability, productivity growth, knowledge and general competencies of employees [7, p. 182]. Digital technologies have also led to the introduction of numerous digital innovations that can be perceived in a narrower and broader sense.

Finally, digital technologies also encourage the application of modern circular solutions, which ultimately, in some kind of integration of digital and circular economy, can lead to the reduction of negative impact on the environment, the boosting of profit growth, the reduction of waste and harmful pollution, and thus the increase of the competitiveness of contemporary companies. Today, the circular economy represents a very popular business concept aimed at reducing the consumption of energy, as well as basic raw materials, non-renewable natural resources and other production inputs. It is a sustainable economic paradigm that decouples economic growth from the use of resources, focusing on recirculation, displacement, waste reduction, recycling, and the most efficient use of resources. In this way, this new business model turned into a completely innovative initiative that encourages digitization, sustainability, resource efficiency, reuse of materials and new patterns of production and consumption [15, pp. 120-127].

On the one hand, there are information and communication technology (ICT) production innovations that occur in the digital sector itself, leading to new or significantly improved ICT products. On the other hand, there are also ICT enabled innovations that are made possible by the use of digital tools, creating new or significantly improved products and processes, new marketing methods, business models, strategies and practices, etc. Finally, of no less importance are the so-called disruptive digital innovations that change already established market patterns in a whole range of industries, manufacturing and service sectors. They raise the level of flexibility of the companies in a highly competitive business environment, driving the overall dynamics of the economy. In this way, digital technologies have shown their revolutionary nature in the change, modernization and innovation of business practices themselves, which is why today's modern concepts of the development of national economies inevitably include a digital element [13, pp. 157-173].

Sustainable development and economic growth are the basic prerequisite for the rise of social well-being and national living standards. The pace and extent of economic growth, among other things, determine the economic position of a society, most often measured by GDP, GDP per capita, national income or employee productivity. At the same time, the processes of globalization, international economic integration, financial and trade liberalization, accelerated industrialization and of handling the environmental issues have led to the rapid development of national economies around the world [5, p. 4]. In the context of these processes, the digitization of the economy plays a special role in the integration of national economies and in encouraging the developmental and organizational strategy of contemporary companies. Many research studies indicate that the digital economy is considered a fundamental trigger in both developed and developing countries. The digital economy is mainly based on the application of modern information and communication technologies (ICTs) that improve business processes, increase the productivity of the production inputs, improve the efficiency of business processes, improve business decision-making and lower general procurement and business costs. Investigating the relationship between investment in ICTs and economic growth on the example of 29 analysed countries during the 1990s, Seo et al. [10, p. 422] proved that there is a positive correlation between these phenomena, especially in countries with better economic infrastructure and an open trade regime that invest more in their digital economy. In doing so, relatively less productive countries can reduce their gap in economic growth by taking advantage of knowledge spillover effects from more advanced countries.

Breakthrough of ICTs has undoubted positive effects on economic growth through encouraging the spread of technologies and innovations, improving the quality of decision-making at the level of micro-entities, through increasing aggregate demand and reducing production costs. At the same time, the diffusion of contemporary ICTs contributes to the change in the production structure and the development of the service sector, while in these processes the most significant role belongs to the penetration of Internet users [6, p. 357]. The role of the digital economy particularly came to the fore after the outbreak of the *Covid-19* coronavirus pandemic, especially in the field of contagion prevention and control, popularization, development and emergence of new digital services, further development of the industry based on ICTs, development of new technologies, etc. However, despite the obvious regional imbalances in the development of the digital economy, its significant positive impact on the economic development of many countries can be observed. The main impact mechanism of the digital economy on economic growth is manifested through the improvement of the industrial structure, digital industry, total employment and employment restructuring [14].

This article is dedicated to the study of the impact of some digital economy indicators on the productivity of workers in the Republic of Serbia (RS) in the period from 2007 to 2021. The scientific contribution of this paper is reflected in the fact that, at least according to the knowledge of its author, no one in Serbia has dealt with these issues so far. The article applies the Autoregressive Distributed Lags (ARDL) approach, as well as the Error Correction Model (ECM) with the aim of determining the long-term and short-term relationship between the domestic digital economy and labour productivity in Serbia. The article is structured as follows: the next section describes the data used, while Section 3 discusses the results obtained in detail. Finally, the last section concludes the paper, with some given recommendations intended for policy makers.

1. Data Used in the Study

The aim of this article is to determine the influence of some digital economy indicators on the trend of workers productivity in Serbia. At the same time, employee productivity is defined as the ratio between GDP and labour force for each calendar year (Figure 1). It is clear from the Figure 1 that labour productivity grew slightly in the observed period. This article uses relatively short time series because the official Statistical Office of the Republic of Serbia (SORS) only recently started to keep track on data on the state of the digital economy in Serbia. The paper considers time series in the period from 2007 to 2021, which makes up 15 observations per one time series. The data used in the research study are derived from the SORS, Eurostat and the World Bank databases.

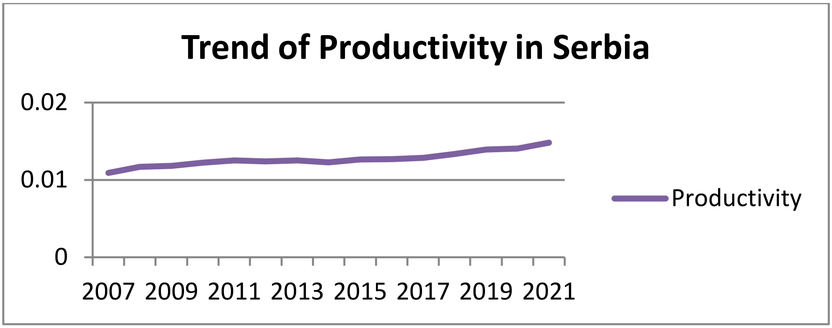

Figure 1. Productivity Trend in Serbia in the Period from 2007 to 2021
Source: Author's figure.

2. Results and Discussion

This study traces the influence of some ICT independent variables on the dependent one GDP per worker (Productivity), which are presented and described in more detail in Table 1.

Table 1. Variables Used in the Research

Variables	Variable cod	Description	Variable type
GDP per worker	Productivity	GDP per worker in constant 2015 US$, in millions of US$	Dependent
Computer programming GVA	Computer programming GVA	Gross value added of Computer programming sector, in millions of US$	Independent
Mobile cellular subscriptions	Mobile phones	Total number of mobile phone subscribers	Independent
Foreign direct investment net inflows	FDI inflows	Foreign direct investment net inflows, in millions of US$	Controlling variable

Government expenditure on education	Education	Total Government expenditure on education, in millions of US$	Controlling variable

The observed variables were first transformed by calculating their natural logarithms with the aim of normalizing and stabilizing the data. In the first step of the analysis, the correlation coefficients between all observed logarithmic variables were calculated in order to determine the strength and direction of their relationship with the dependent variable Productivity, but also to avoid the possible problem of multicollinearity between the explanatory variables. Table 2 presents the matrix of obtained correlation coefficients.

Table 2. Correlation Coefficient Matrix between Observed Variables

Correlation Prob.	Ln (Productivity)	Ln (Computer programming)	Ln (Mobile phone users)	Ln (FDI net inflows)	Ln (Education)
Ln (Productivity)	1.0000				
Ln (Computer programming)	0.8995* 0.0000	1.0000			
Ln (Mobile phone users)	-0.5038 0.0555T	-0.7641* 0.0009	1.0000		
Ln (FDI net inflows)	0.2289 0.4120	0.2342 0.4008	-0.3036 0.2712	1.0000	
Ln (Education)	0.1950 0.4861	-0.0849 0.7634	0.1975 0.4805	0.3074 0.2650	1.0000

Note: * Denotes statistically significant correlation relation at the level of 5% significance.
T Denotes the threshold value of statistical significance.

Source: Author's calculations.

A clear conclusion follows from the conducted correlation analysis that the computer programming sector has the strongest, positive and statistically significant impact on worker productivity ($r = 0.8995,\ p = 0.0000$), while it is followed by a somewhat weaker negative impact of the mobile phones' use on GDP per worker, at the very threshold of its statistical significance ($r = -0.5038$, $p = 0.0555$). At the same time, it seems that there was no pronounced problem of multicollinearity between the observed control variables, since their bivariate correlation coefficients ranged up to the value of $r = -0.7641$. Otherwise, the problem of multicollinearity occurs in those cases when the independent variables are in a very strong mutual correlation relationship, that is, when their correlation coefficient is 0.9 or above. In that case, literature sources recommend the deletion of one of the two redundant variables from the model [12, p. 89].

In the next step, the paper approached to the application of the unit root test, more specifically the use of the Augmented Dickey-Fuller (ADF) test to determine which of the variables were I(0) or I(1) since the Autoregressive Distributed Lags (ARDL) Model allows the simultaneous use of both type of variables in the analysis. The aim of conducting the ADF test was also to determine whether some of the observed variables were I(2), i.e. integrated of order two, in which case they could not be included in the ARDL Model. Table 3 indicates the results of the applied Augmented Dickey-Fuller unit root test.

Table 3. Augmented Dickey-Fuller Unite Root Test Results

	Level variables		First differenced variables		Second differenced variables	
Variables	ADF test statistic	Prob*	ADF test statistic	Prob*	ADF test statistic	Prob*
Ln (Productivity)	-1.9312	0.5724	-4.3470*	0.0061	-7.1228*	0.0001

Ln (Computer programming)	-3.6568	0.0731	-3.7347*	0.0189	-3.8848*	0.0164
Ln (Mobile phone users)	-4.7181*	0.0172	-6.3924*	0.0006	-6.0592*	0.0014
Ln (FDI net inflows)	-3.1917	0.1256	-6.9961*	0.0001	-5.2101*	0.0029
Ln (Education)	-1.4581	0.7943	-1.3590	0.5621	-2.0392	0.2679

Notes: Level estimations of the Dickey–Fuller regressions include an intercept and a linear trend. First differences of the Dickey–Fuller regressions include an intercept, but not a trend.
* Denotes rejection of a unit root at the level of 5%.
T Denotes the threshold value of statistical significance.
Source: Author's calculations.

Given that the ADF test showed that the logarithmic variable Education was I(2), it had to be excluded from further analysis due to the requirements and initial assumptions for applying the ARDL approach. Bearing in mind that the logarithmic variable Mobile phone users was I(0), as well as that the remaining variables were I(1), i.e. stationary in their first differences and following the approach by Bahmani-Oskooee et al. (2016, pp. 24-25) only these remained variables were further considered in this research.

After this step, the structural breaks were tested in the observed time series using the CUSUMSQ test and the Chow Breakpoint Test. Namely, one of the requirements of the ARDL technique refers to the absence of structural breaks in the used data series. The results of the applied structural break tests are shown in the following Table 4.

Table 4. Results of the Structural Break Tests

Variables	CUSUM of Squares Test at 5% significance	Chow Breakpoint Test results		
	CUSUM of Squares Chart Status at 5%	F-statistic	Probability	Break at specified breakpoints

	significance			
Ln (Productivity)	OK – within the permitted limits	2.8492	0.1007	No breakpoints
Ln (Computer programming)	OK – within the permitted limits	1.0562	0.3805	No breakpoints
Ln (Mobile phone users)	OK – within the permitted limits	3.1355	0.0836	No breakpoints
Ln (FDI net inflows)	Outside the permitted limits	13.6552* 13.5119* 17.2229* 20.9074* 16.6733* 9.1967*	0.0010 0.0011 0.0004 0.0002 0.0005 0.0045	There are breakpoints in 2010, 2011, 2012, 2014, 2017 and 2019

* Denotes statistically significant F-statistic value.
Source: Author's calculations.

Since it was determined in this step that the independent logarithmic control variable FDI net inflows had a couple of structural breaks in 2010, 2011, 2012, 2014, 2017 and 2019, it had to be excluded from further analysis. With these steps, it was proved that all the necessary prerequisites for applying the ARDL Model of cointegration among the remaining variables were met. In the next step, Johansen's cointegration test was applied among the remaining variables at a level that indicated that there was very likely at least one cointegrating relationship among the observed variables at a significance level of 5%, as indicated by the results of the Trace test and Maximum Eigenvalue Test from Table 5.

Table 5. The Results of the Johansen Cointegration Test among the Observed Variables

Null hypothesis: no cointegration	Eigenvalue	Trace Statistic	0.05 Critical Value of	Prob. **	Max-Eigen Statistic	0.05 Critical Value of	Prob. **

			Trace Statistic			Max-Eigen Statistic	
None *	0.921335	46.82144	35.01090	0.0018	33.05328	24.25202	0.0027
At most 1	0.649264	13.76816	18.39771	0.1971	13.62037	17.14769	0.1518
At most 2	0.011305	0.147797	3.841466	0.7006	0.147797	3.841466	0.7006

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Source: Author's calculations.

After this step, the differentiation of variables was approached, which was followed by the formulation of a non-restrictive Error Correction Model (ECM) in the form of a special type of ARDL Model. The equation of the conventional ECM model for cointegrated data has the following form:

$$\Delta Y_t = \beta_0 + \sum \beta_i \Delta Y_{t-i} + \sum \gamma_j \Delta X_{1t-j} + \sum \delta_k \Delta X_{2t-k} + \varphi z_{t-1} + e_t \qquad (1)$$

where the sums from Equation (1) range from $= 1, \dots, p$, $j = 0, \dots, q_1$ i $k = 0, \dots, q_2$ respectively, where e_t is the error term, β_0, β_i, γ_j and δ_k are the coefficients of the model, while the parameter z represents the error-correction term that can be written by the following equation:

$$Y_t = \alpha_0 + \alpha_1 X_{1t} + \alpha_2 X_{2t} + v_t \qquad (2)$$

Based on Equation (1) and Equation (2), the final formulation of the non-restrictive ECM technique was approached, which takes the following form [3]:

$$\Delta Y_t = \beta_0 + \sum \beta_i \Delta Y_{t-i} + \sum \gamma_j \Delta X_{1t-j} + \sum \delta_k \Delta X_{2t-k} + \theta_0 Y_{t-1} + \theta_1 X_{1t-1} + \theta_2 X_{2t-1} + e_t \quad (3)$$

After that step, the article approached to the evaluation of the Vector Autoregression (VAR) Model with the aim of determining the optimal length of lags in the observed time series in a time-efficient manner. By applying many information criteria[†], and above all the most reliable and consistent Schwarz information criterion (SIC), it was concluded that the optimal number of lags for independent variables was 1, while the optimal number of lags for the dependent variable Productivity was 2. This selection of lags length also corresponded to the fact that the data on the considered time series were on an annual basis. Checking the dynamic stability of this VAR model gave satisfactory results, with all roots remaining within the unit circle (Figure 2).

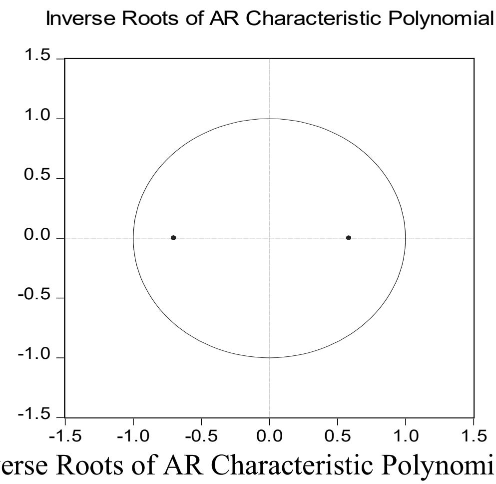

Figure 2. Inverse Roots of AR Characteristic Polynomial

[†] LR: sequential modified LR test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike information criterion and HQ: Hannan-Quinn information criterion.

Source: Author's calculations.

After this procedure, the article proceeded to estimate the non-restrictive ECM technique through the Ordinary Least Squares (OLS) Method, with the following results obtained (Table 6).

Table 6. Results of the Estimated Non-restrictive ECM Technique

Variables	Coefficient	Standard Error	t-Statistic	Prob.
C	-3.501640	13.86960	-0.252469	0.8131
D(Lnproductivity(-1))	0.304429	0.691053	0.440529	0.6823
D(Lnproductivity(-2))	0.602700	0.454971	1.324699	0.2559
D(Lncomputer programming(-1))	-0.058576	0.077417	-0.756632	0.4914
D(Lnmobile phones(-1))	-0.247769	0.469462	-0.527773	0.6256
Lnproductivity(-1)	-0.539111	0.527429	-1.022149	0.3645
Lncomputer programming(-1)	0.078248	0.127834	0.612109	0.5736
Lnmobile phones(-1)	0.040939	0.742347	0.055149	0.9587

Source: Author's calculations.

A key assumption in the methodology of the ARDL model developed by Pesaran et al. (2001) is that the errors in Equation (3) must be serially independent, that is, there should be no autocorrelation in them. Checking the autocorrelation in the model using the Breusch-Godfrey Serial Correlation LM Test showed the fact that there was no serial correlation in the non-restrictive ECM ($F-statistic = 5.5944$, $p = 0.1516$), indicating the possibility of continuing this analysis. In addition, the application of the CUSUM test, as well as the CUSUM of Squares Test at a significance level of 5% showed that it was a dynamically stable model, stipulating the stability of the estimated coefficients and the absence of the problem of recursive residuals (Figure 3).

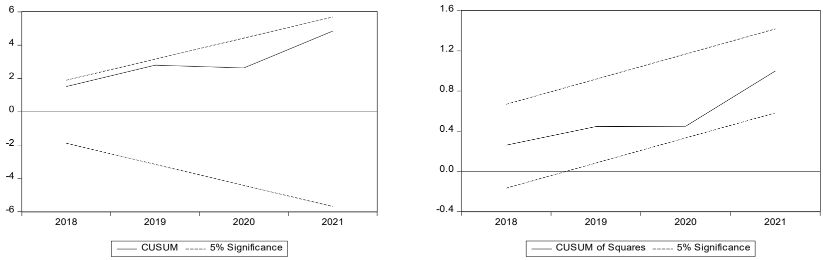

Figure 3. Results of CUSUM and CUSUM of Squares Test
Source: Author's figures.

This non-restrictive EC model was relatively well fitted, as indicated by the appearance of the actual and fitted residuals (Figure 4).

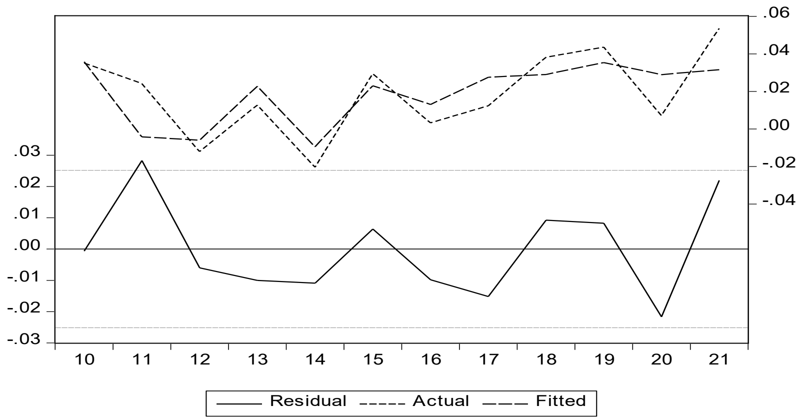

Figure 4. Actual and Fitted Residuals
Source: Author's figure.

The article then proceeded to apply the Bounds test itself with the aim of testing the absence of a long-term equilibrium relationship between the observed variables. More precisely, the Wald test was used to test the null hypothesis about the equality of the long-term coefficients of the three used variables with zero $H_0: \theta_0 = \theta_1 = \theta_2 = 0$. The value of the obtained F-statistic was $F = 0.9590$, with a probability of $p = 0.4933$. By comparing this value of the F-statistic with the critical values of the Bounds test from the article by Pesaran et al. (2001, p. 300) for the level of statistical significance of 5%, for the number of independent variables $k = 2$, and for the case of restricted intercept and no trend, it was concluded that it was lower than the lower bound in the amount of 3.10 [9, p. 300]. This result indicated that there was no long-term cointegration relationship between these variables, disputing the results of the applied Johansen's cointegration test.

Despite this, the estimation of the ARDL(1,0,0) model with variables at the level was also approached in order to draw some orientation conclusions about the ultimate impact of independent variables on productivity (Table 7).

Table 7. Results of the Estimated ARDL Model with Level Variables

Variables	Coefficient	Standard Error	t-Statistic	Prob.
C	-4.369245	6.316872	-0.691679	0.5049
Lnproductivity(-1)	0.564122	0.274139	2.057797	0.0666
LnComputer programming	0.067804	0.061923	1.094976	0.2992
LnMobile phones	0.127844	0.335571	0.380974	0.7112

Source: Author’s calculations.

As can be seen from Table 7, it seems that neither the computer programming sector nor the use of mobile phones contribute significantly to the growth of worker productivity in Serbia, which confirms the thesis that there is no long-term cointegration relationship between these variables. At the same time, from the Table 7 arises only the stand that productivity from the previous year contributes positively and significantly up to 10% to the current productivity of workers.

Finally, the article approached the construction of the restrictive ECM technique using the obtained series of residuals z_t, the results of which are shown in Table 8.

Table 8. Results of the Estimated Restrictive ECM

Variables	Coefficient	Standard Error	t-Statistic	Prob.
D(Lnproductivity(-1))	0.443441	0.293852	1.509064	0.1750
D(Lnproductivity(-2))	0.648716	0.217404	2.983927	0.0204
D(Lncomputer programming(-1))	-0.064000	0.056076	-1.141319	0.2913
D(Lnmobile phones(-1))	-0.409153	0.196112	-2.086319	0.0754
Z(-1)	-0.627591	0.289689	-2.166429	0.0670

Source: Author's calculations.

As can be seen from the given Table 8, the obtained coefficient of the error-correction term z_{t-1} was negative, it was in the allowed range of $-1 < z_{t-1} < 0$ and was statistically significant to a level of up to 10% ($p = 0.0670 < 0.10$), indicating the existence of a short-term relationship between the observed variables. The magnitude of this coefficient implies that almost 63% of any imbalances among the observed variables are corrected within a period of one year.

The subsequent diagnostics of this model gave desirable and satisfactory results. First, the Breusch-Godfrey Serial Correlation LM Test was conducted, which suggested that there was no serial correlation in the model residuals (F-statistic = 1.1779, p = 0.3809 > 0.05). After that, the Jarque-Bera normality distribution test was applied, which indicated a normal distribution of residuals (Jarque-Bera = 1.3384, p = 0.5121 > 0.05). Finally, the article applied the Breusch-Pagan-Godfrey heteroscedasticity test, which showed the presence of homoscedasticity among the residuals (F-statistic = 0.5339, p = 0.7461 > 0.05). Finally, the application of the CUSUM Test and the CUSUM of Squares Test, as well as their graphs pointed to the stability of the model (Figure 5). The analysis indicated that there were no recursive residuals in the model at the 5% significance level.

Among other things, this restrictive EC model was relatively well fitted, as indicated by the relatively good matching of the actual with fitted residuals (Figure 6). Although it confirmed the existence of a short-term relationship between the digital sector and employee productivity up to the 10% significance level, this analysis did not prove a long-term relationship between these variables. The reason for this lies in the fact that the digital sector has only recently begun to develop more seriously in Serbia, as well as in the fact that its share in the country's GDP is still very small. For example, in the period from 2007 to 2021, the share of the computer programming sector in GDP was only about 1.6%.

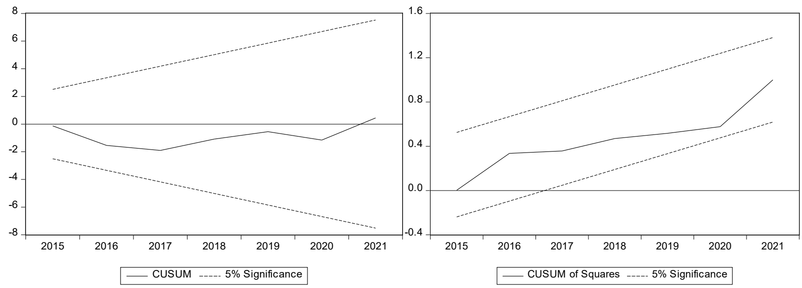

Figure 5. CUSUM and CUSUM of Squares Plots
Source: Author's figures.

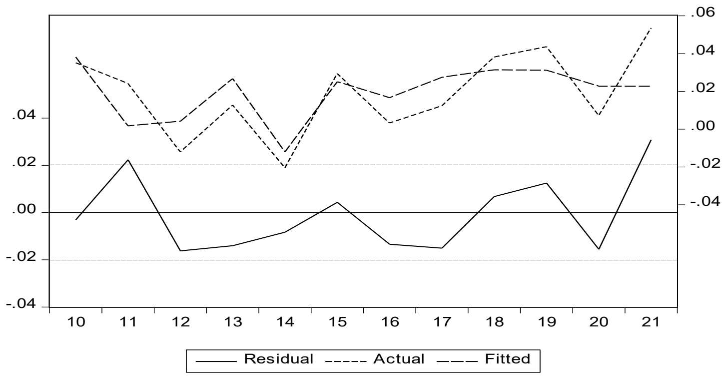

Figure 6. Actual and Fitted Residuals of Resrected ECM
Source: Author's figure.

The objective limitation of this study is related to the fact that short time series were used, given that the statistics of digital data in Serbia are only recently started to be kept comprehensively. This is also the reason for the fact that in this analysis time series are observed only in the period from 2007 to 2021. Future research on this problem could explore and take into account the asymmetric impact of IT indicators on the movement of worker productivity in Serbia using the Nonlinear ARDL (NARDL) model.

Concluding Remarks

In this article, the impact of the digital economy on the trend of employee productivity in Serbia in the period from 2007 to 2021 was researched. The article applied the ARDL approach to cointegration with the aim of examining the long-term relationship among the observed variables, as well as the Error correction model with the aim of determining their short-term relationship among them. Application of the ARDL and EC models indicated that, although there is no long-term cointegrating relationship among the computer programming sector, mobile phone use and worker productivity in Serbia, their short-term relationship is still present. The latter conclusion stems from the fact that the error correction term $Z(-1)$ was negative and statistically significant up to the significance level of 10%. These results are consistent with the fact that the digital sector of Serbia is still in its infancy, and that it still has a small share in the national GDP and the generation of value added. However, we should also add the fact that a statistically significant positive impact on the productivity of workers in Serbia was shown by their productivity from the previous year, indicating a significant autoregressive component of this explanatory variable.

Therefore, the digital economy of Serbia should be further developed in order for it to grow into one of the basic tools of the development of society, and therefore of competitiveness and the economy as a whole. In this sense, the state should play an active role in developing appropriate legal solutions and encouraging domestic and foreign investments that would bring digital-technological innovations and new jobs. The government should also increase investments in research and development (R&D), various forms of intellectual property, digital innovation and digital transformation, as well as encourage new tax reliefs and support programs, especially since only about 25% of domestic firms have achieved digital transformation. At the same time, about 40% of companies achieved and used innovations without digital transformation. However, the number of Serbian companies that have their own web page, as well as online trade channels is continuously increasing, while almost all companies in Serbia have an Internet connection. This is more than encouraging. In order to develop the domestic digital economy, the state should encourage further investments in R&D and innovation, the creation of a local venture capital industry, to stimulate of cooperation between science and business, but also to insist on the practical application of artificial intelligence in all spheres of society [11, pp. 1-24]. All these efforts, viewed together, could speed up the process of digital transformation of Serbian society, and therefore its impact on the productivity of employees in Serbia.

Bibliography

1. Bahmani-Oskooee, H., Ferda, H., Scott W. 2016. Mexican bilateral trade and the J-curve: An application of the nonlinear ARDL model. *Economic Analysis and Policy*, 50(2016), pp. 23-40. http://dx.doi.org/10.1016/j.eap.2016.02.003
2. Dickey, D. A., Fuller, W. A. 1979. Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, 47, pp. 427-431.
3. Giles, D. 2013. Dave Giles' Blog, ARDL models – PART II – Bounds Tests, June 19, 2013. Retrieved from: https://davegiles.blogspot.com/2013/06/ardl-models-part-ii-bounds-tests.html [access: June 5, 2023]

4. Johansen, S. 1991. Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models. *Econometrica*, 59(6), pp. 1551-1580.
5. Jurayevich, M. B., Bulturbayevich, M. B. 2020. The Impact of Digital Economy on Economic Growth. *International Journal of Business, Law, and Education*, Vol. 1, No. 1, August 2020, pp. 4-7.
6. Khuong, V. M. 2011. ICT as a source of economic growth in the information age: Empirical evidence from the 1996–2005 period. *Telecommunications Policy*, Vol. 35, Issue 4, May 2011, pp. 357-372. https://doi.org/10.1016/j.telpol.2011.02.008
7. Madžar, L. 2022. Stanje digitalne privrede u Srbiji. *Naučno-stručna konferencija Trendovi u poslovanju 2022*. Kruševac: Visoka poslovna škola strukovnih studija „Prof. dr Radomir Bojković“ Kruševac i Biznis inkubator Kruševac, str. 181-190.
8. Pesaran, M. H., Shin, Y. 1999. An autoregressive distributed lag modelling approach to cointegration analysis. Chapter 11 in S. Strom (ed.), *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*. Cambridge: Cambridge University Press.
9. Pesaran, M. H., Shin, Y., Smith, R. J. 2001. Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16, pp. 289–326.
10. Seo, H. J., Lee, Y. S., Oh, J. H. 2009. Does ICT investment widen the growth gap?. *Telecommunications Policy*, Vol. 33, Issue 8, September 2009, pp. 422-431. https://doi.org/10.1016/j.telpol.2009.04.001
11. Stefanović, M., Đorđević, I., Milosavljević, N., Đonović, A. 2022. Analiza stanja inovacija i procesa digitalne tranformacije u Republici Srbiji, Mart 2022. godine. Beograd: NALED.
12. Tabachnick, B. G., Fidell, L. S. 2013. *Using Multivariate Statistics*, Sixth Edition. Boston: Pearson.
13. Vidas Bubanja, M., Madžar, L. 2019. The Importance of Innovation and Knowledge for Economic Development of the Country and the Competitive Business of Companies. *Glasnik za društvene nauke*, God. 11, Br. XI(2019), str. 157-173.

14. Zhang, J., Zhao, W., Cheng, B., Li, A., Wang, Y., Yang, N., Tian, Y. 2022. The Impact of Digital Economy on the Economic Growth and the Development Strategies in the post-COVID-19 Era: Evidence From Countries Along the "Belt and Road". *Frontiers in Public Health*, Vol. 10, 2022. https://doi.org/10.3389/fpubh.2022.856142
15. Madžar, L. 2021. The Concept, Principles and Innovations in Circular Economy. *Glasnik za društvene nauke*, Vol. XIII, No. 13, pp. 120-133.

UTICAJ DIGITALNE PRIVREDE NA PRODUKTIVNOST RADA U SRBIJI: PRIMENA ARDL I ECM PRISTUPA

Apstrakt
Prodirući u sve aspekte svakodnevnog života, digitalne tehnologije su promenile način života, poslovanja i ponašanja ljudi. One utiču na razvoj privrede i društva omogućavanjem pristupa informacijama i resursima, povezivanja, efikasnijeg procesa donošenja odluka, finansijske inkuzije, naprednijih poslovnih strategija, kao i boljeg pristupa trgovini i javnim uslugama. Digitalna transformacija podstiče saradnju, fleksibilnost, komunikaciju, efikasnost i agilnost, ali i inovacije, upravljanje konfliktima, održivost poslovanja, rast produktivnosti, znanje i opšte kompetencije zaposlenih. Sa druge strane, produktivnost rada opredeljuje konkurentnost, tempo napretka i kvalitet same privrede. Svrha ovog članka je da istraži dugoročnu i kratkoročnu vezu između nekih indikatora digitalnog sektora i produktivnosti rada u Srbiji u periodu od 2007. do 2021. godine. Dok je primenjeni Model autoregresivnih distribuiranih docnji (ARDL) ukazao na to da nema dugoročne veze između ovih fenomena, primenjeni Model korekcije greške (ECM) je ukazao na njihov kratkoročni odnos. Takođe je

uočeno i da prošlogodišnja produktivnost zaposlenih statistički značajno i pozitivno opredeljuje njihovu trenutnu produktivnost. Članak zaključuje da bi vlada trebalo i dalje da podstiče razvoj digitalne privrede kako bi ona prerasla u jednu od osnovnih poluga rasta i razvoja društva, a samim tim i konkurentnosti privrede u celini.

Ključne reči: *informaciono-komunikacione tehnologije (IKT), digitalna privreda, ARDL i ECM modeli, produktivnost rada, digitalna transformacija.*

JEL klasifikacija: C32, L86, O00, O30